

Students' Cognitive Perception of Landscape Features: Empirical Research Using Cognitive Maps

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Abstract: This article focuses on a study of the importance of maps in shaping the geographical perceptions of Slovenian primary- and secondary-school students, and on how they depict their perceptions of geographical reality on cognitive maps. It primarily addresses what perceptions children of various ages can develop about landscape features and other characteristics in their country, what influences their development of spatial imagery, conceptualizations, and evaluations, and how maps can help them in this regard. The research method applied included a semi-structured questionnaire and students were asked to draw cognitive maps. The analysis of the differences in perceiving space and in the drawing techniques used by ten- to seventeen-year-old students yielded several interesting results. From the cartographic perspective, compared to secondary-school students, primary-school students tended to not only describe their concepts, but also more frequently draw them, and they also colored their maps. In cases where landscape features were drawn, the students most often used abstract point symbols (dots, circles, and crosses), for line symbols they used solid lines, and for area symbols they used uncolored polygons. There were hardly any perceptible sex differences in the choice of cartographic symbols. Their pictures were a good approximation of their spatial perception or understanding of nearby and more distant landscapes, they showed their locational precision (or lack of precision) in positioning features in space, and they also reflected the concepts they had learned in school and, to a lesser extent, the influence of their home environment. Specifically, regardless of where the students went to school, in terms of content their cognitive maps most frequently included the same features (e.g., the Slovenian capital, the highest Slovenian mountain, Postojna Cave as the most important Slovenian tourist site, and so on), rather than natural and cultural features from their home environment.

Keywords: Cartography, Mental image, Cognitive map, Spatial perception, Slovenia

1. Introduction

In the second half of the twentieth century, many cartographic theorists (e.g., Koláčný 1969; Robinson and Bartz Petchenik 1975; MacEachren 1995) dealt with the principles of transferring information within the cartographic communication system and with key components of this system. Far fewer researchers (e.g., Harley 1989; Montello 2002) have addressed how maps as media for transferring coded messages from the cartographer to the user impact the expansion of users' perceptions of geographical reality and their mental images. Even though cartography and psychology usually treat the terms "mental map or image" and "cognitive map" as synonyms, this article makes a strict distinction between the two. People constantly receive new information from their surroundings through their senses. The nervous system transmits a given part of that information to the brain, which stores it as mental pictures. Cognitive maps are understood here as replications of an individual's mental image enriched with his or her own insights.

Limitations in perception, selection, and interpretation on the part of both cartographers and map users have led to discrepancies between geographical reality on the one hand and users' perception of reality on the other. It was

shown that the development of spatial imagery, conceptualizations, and evaluations is influenced by the home environment, school, the media, and the social system. Individuals' perceptions also depend on their age, personal characteristics, and physical limitations (e.g., blindness or deafness). In this regard, it is vital that cartographers be aware of users' limitations and take them into account when designing maps.

In contrast, it is recommended that users also understand cartographers' limitations. The first type of limitation is of a technical nature because a reduced scale of representation makes it impossible to present all available spatial features and therefore every map is subject to a specific degree of generalization in terms of scale and purpose. A further limitation is the fact that the Earth's round surface is most often projected to the flat surface of paper, which inevitably causes distortions in lengths, angles, and areas. A subjective cartographic message can also be conveyed by highlighting certain features, omitting contradictory information, and/or selecting provocative cartographic symbols. The second type of limitation is of a personal nature, when cartographers imprint the values and beliefs of their clients or the society they operate in onto the map. This is the more evident when the map is observed from a certain chronological distance. A subjective cartographic representation most often refers to territorial demands, ethnicity, borders, strategic locations, conquered territories, defense positions, spheres of interest, and regional differences (Monmonier 1996, 87). However, this last type of limitation can also be observed with user perceptions and interpretations.

Hence, every map is both an interpretation of geographical reality and its distorted image, which clearly influences the spatial perceptions of its users. This influence is even more pronounced with children, who are only beginning to build their cognitive worlds using new knowledge of spatial perceptions, which they also obtain by reading maps.

2. Maps as instruments for improving spatial perceptions

Some authors emphasize the importance of maps for developing spatial perceptions and improving people's cognitive skills because reading maps requires complex thinking and numerous mental operations (Kimberly 2011; Hergan and Umek 2013). The level of cognitive skills itself is connected with the number of synapses (i.e., junctions between nerve cells). Considering that children are exceptionally susceptible to specific tasks and learning during the period when new synapses are being created, it makes sense to offer them maps as early as possible in order not to miss the positive effects they may have on children's later intellectual skills. Specifically, approximately 50% of synapses are created by age five and 75% by age seven (Jurišević, Rajović and Drgan 2010, 5). In addition, at age seven the eyesight is nearly as sharp as in an adult, and the width of the visual field that affects peripheral vision is also similar to that of an adult (Ivić et al. 2002). This is also a precondition for properly recognizing different colors, distinguishing between pictures, identifying a simple picture within a complex picture, distinguishing highlighted features from the background, and so on. Hence, at the time they start primary school, healthy children already have developed physical and psychological skills of active cognitive exploration. However, children at this age are by no means yet able to fully decipher the content of the map, analyze and interpret its meaning, understand the design techniques used, and apply new knowledge in practice.

Various literature, computer games, online interactive maps, and even open-access GIS programs have become freely available over the past twenty years, and so today's children encounter maps at a significantly early age. Therefore, one could incorrectly conclude that by the time they start primary school they have better spatial perceptions and a higher level of cartographic knowledge than children had in the past. In fact, experts emphasize that in general the use of a global navigation satellite system (GNSS) for moving in space decreases the skills of reading and interpreting maps (Maxwell 2013). People's spatial perceptions and mental images are therefore less clear because they rely on navigation devices and no longer perceive space in all of its magnitude.

Teachers are especially important for complementing the global perception of the world, which children cannot yet experience personally, because it is precisely at school that they can learn the most about this subject. Therefore, teachers must continually keep abreast of technological advances and improve their cartographic skills because they must help students (especially younger ones) decode the cartographer's message on the map.

2.1 The importance of using maps from students' and teachers' perspectives

In addition to the cartographer, map users also play an important role in the cartographic communication system because their needs, knowledge, and perception determine how successfully they decode the coded messages, what they assign meaning to, and what they store as pictures in their minds. As part of the study on the importance, applicability, and appearance of maps, a survey was thus conducted among primary- and secondary-school students and their teachers. This is one of the most common non-experimental methods used in educational research.

The survey was carried out at nine primary schools and eight secondary schools from April to June 2013 (Fig. 1). The questionnaires were completed by fifth and ninth graders (ten and fourteen years old) and first- and third-year secondary-school students (fifteen and seventeen years old). The teachers and students received the semi-structured questionnaires in paper form. The author did not opt for an online survey because the goal was to obtain information about the students' personal perceptions, especially by asking them to draw their cognitive maps without using textbooks, maps, or any other learning aids.

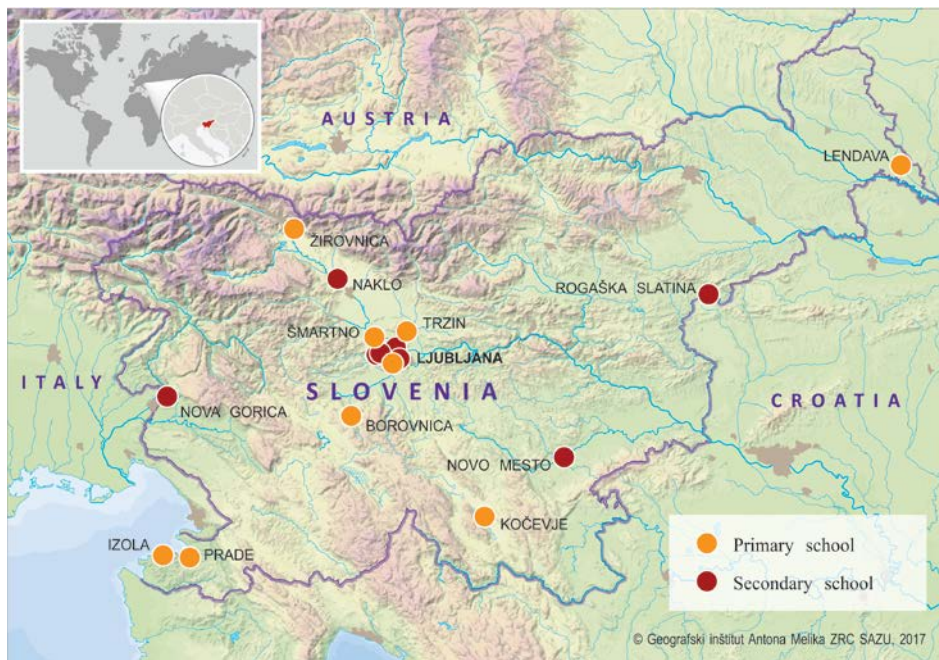


Fig. 1. Spatial distribution of the sample of schools surveyed.

The survey included 722 students, or 338 girls and 378 boys. Six respondents did not provide information on their sex (Table 1). The participating teachers included twenty-six women and two men, mostly social science and geography teachers, who were teaching the grades surveyed. The survey covered schools across all types of Slovenian landscapes (Alpine, Prealpine, Mediterranean, Pannonian, and Dinaric-karst landscapes).

Table 1. Data on the statistical sample of students included in the survey

Grade/Year	Boys	Girls	No sex indicated	Number of respondents	Share of respondents
5 (primary school)	101	114	3	218	30.2%
9 (primary school)	81	74	1	156	21.6%
1 (secondary school)	90	80	0	170	23.5%
3 (secondary school)	106	70	2	178	24.7%
Total	378	338	6	722	100.0%

Respondents used a Likert scale (Fig. 2) to indicate the importance they ascribed to pictorial material, including maps. Among them, 19.1% indicated that this type of material was very important to them when studying about Slovenia, and nearly half (44.2%) replied that it was important to them. The material was moderately important to 28.8% of respondents and, if this share is added to the previous two, the final share of positive responses is very high. On the other hand, only 54% of students indicated that the material was of little importance to them and 1.2% reported that it was unimportant. If all of the responses ranging from moderately important to very important are interpreted as positive, the pictorial material in textbooks was positively assessed by the majority of students (92.1%) and all the teachers surveyed. Their scores also match the findings by Gersmehl (2008) and Scoffham (2013), who highlight the importance of suitable pictorial material in textbooks for shaping spatial perceptions.

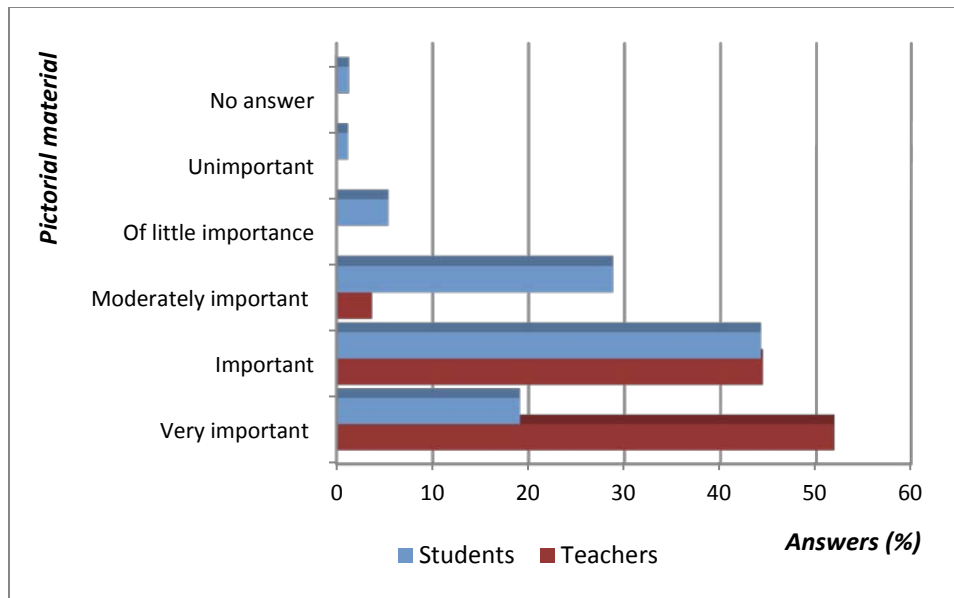


Fig. 2. Students' and teachers' opinions on the importance of pictorial material.

Even though decades ago maps were primarily considered tools that help people orient themselves in space and determine the location of a specific place, the students' responses (Fig. 3) show that this is actually what they use them for the least. This may also result from the fact that since the emergence of navigation devices there has been less need to use maps for orientation because now users can simply follow the device's instructions. Students most often use maps for reviewing material learned in school, whereby girls more often chose the answer "very important" and "important" compared to the boys. For the question assessing the frequency of map use students could choose among five responses to circle, including the category "Other," where they could write down what other purposes they use maps for. However, 77.8% of respondents that circled the category "Other" on the Likert scale did not write down anything on the line provided. Among the rest, 6.8% wrote that they use maps for school, 5.7% for looking up places, mountains, countries, and other points of interest, 4.2% for planning their free-time activities, 2.9% for outdoor orientation, and 1.4% for other purposes; 1.2% wrote that they do not use maps at all. Even though the administrators hoped that under the category "Other" the students would also list other reasons for using maps and not just the ones already provided, they largely repeated answers that actually belonged to one of the previous four categories.

Teachers were also asked to present their opinion on when children should start using maps. They must have had the current school maps in mind because none of them selected the answer "in preschool (at age five or earlier)," even though it is being increasingly highlighted in teaching practice that the development of cartographic skills should already begin in early childhood—first through simple maps on which children look for a treasure or try to find their way out of a maze.

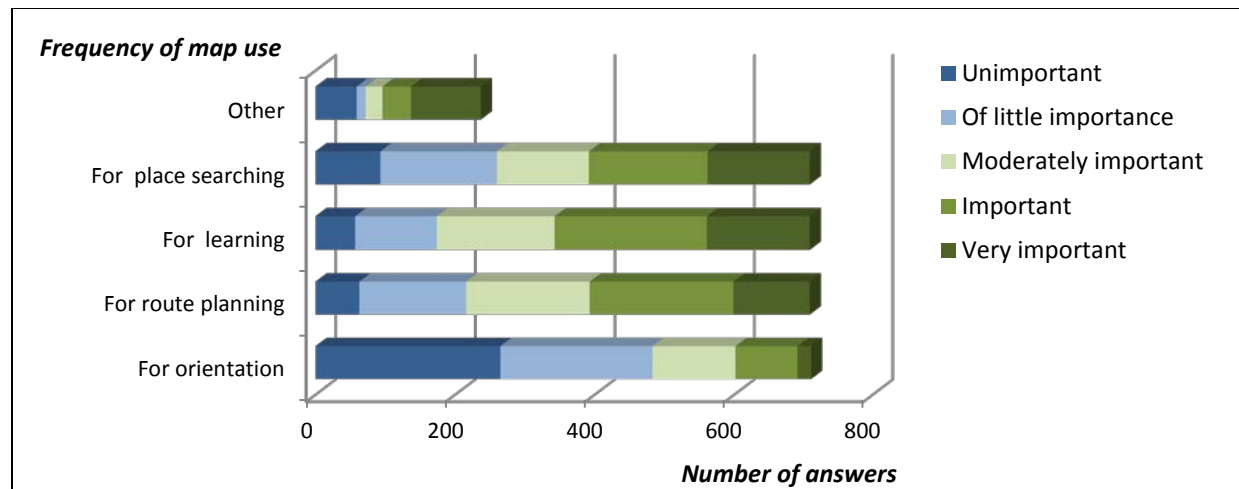


Fig. 3. Purpose and frequency of students' map use.

3. Cognitive maps as instruments for verifying spatial perceptions

Spatial perceptions are closely connected with the development of people's thinking. The Swiss psychologist Jean Piaget, who was the first to systematically investigate cognitive development and advocated the idea that children think differently than adults, distinguished between four qualitatively different universal stages of cognitive development (McLeod 2015). The concrete operational stage proved especially relevant for this empirical study. In general, this stage represents the main turning point in the cognitive development of children between seven and eleven, in which children can imagine things even before they personally encounter them in the real world. Children at this age have predominantly concrete and live perceptions that are, however, still fairly unclear and incomplete because children still lack sufficient experience. Only through education do their spatial perceptions become clearer and more complete because they complement and reshape them or create new ones. The majority of students only develop the ability to think logically and acquire moral and social skills in their early-to-mid teenage years.

Piaget's stages of cognitive development also partially overlap with the four developmental stages of children's mapping skills introduced by Simon Catling (1983, 13–20). Many studies of children's map drawing and reading skills showed that children begin to understand maps around age two, when they enter the preoperational stage of cognitive development or the stage of egocentric understanding of space. The latter means that the majority of spatial structures are derived from their home as the center of their drawing. At age six or seven, when the concrete operational stage of cognitive development begins, children already form specific spatial conceptions based on their own experience, but they continue to be egocentrically oriented. When they start school, children obtain more opportunities to gain cartographic experience, and so education accelerates their transition into the developmental stage of objective spatial perception. They understand familiar spaces much better and can also draw them fairly accurately, but they cannot yet understand various spatial phenomena and the connections between them within larger spatial dimensions. Around age ten (and only rarely earlier than that), transition into the formal operation stage of cognitive development begins and, at the same time, the phase of abstract understanding of space (Catling 1979).

3.1 The inductive method of drawing cognitive maps

The ability of ten- to seventeen-year-old students to perceive, understand, and abstract geographical reality was examined using the inductive method. This research method was applied to determine the kinds of perceptions that children of different age groups had developed about landscape characteristics. Therefore, students that had already

entered the last or formal operational stage of cognitive development were also asked to draw cognitive maps as part of the survey. The analysis of cognitive maps was selected because these most faithfully represent individuals' internalized mental images.

Similar to how a map is not an actual reflection of geographical reality due to technical limitations and the cartographer's subjectivity, cognitive maps are also not a completely faithful representation of the mental image of those that draw them because they also reflect cartographic experience, values, and one's mood at the time.

The cognitive depictions of students' mental world were examined using a blank outline map of Slovenia. The students' task was to draw or write special features and characteristics of Slovenia on it that they might like to show to a new friend from abroad that is unfamiliar with their country. The blank map of Slovenia was incorporated into the survey immediately after the introductory motivational questions for two reasons. First, in this way the questions that followed would not influence the material the students entered on the map, and, second, at the beginning of the survey the students were still sufficiently motivated to complete more complex mental tasks. They had five minutes available to complete the maps, but some students finished their assignment even sooner than that.

3.2 Methods of depicting spatial perceptions

In addition to the material the students depicted on the blank maps, the approaches they used for "drawing" maps were also examined. Slovenia's territory on the map was marked with the national border, and so the area in which students could mark their spatial perceptions covered the entire country (Fig. 4). It was predicted that they would primarily focus on landscapes more familiar to them.

Data processing was very time consuming and demanding because all of the landscape features and characteristics that the students wrote down or drew on their maps had to be entered into a spreadsheet. A survey reference number was added to each item and the text from individual units was copied precisely the same way as the students had written it (in small letters or all caps), including any grammatical errors. With regard to pictorial symbols, the symbol that the student used to depict a specific landscape feature (e.g., a geometrical, pictorial, line, or area symbol) was provided, along with what it represented (e.g., a dot, circle, the Aljaž Tower on Mount Triglav, a tree, a castle, hills, a lake with an island in the middle, etc.). A transparency was used to determine the natural geographical landscape into which the student drew or wrote a selected features and characteristics.

Using the survey reference numbers, information on the students' sex, school grade or year, and the natural geographical landscape where they attended school was added to all of the units entered (i.e., 11,358 altogether). The 374 maps completed by primary-school students contained 3,530 text entries, or an average of 9.4 items written per student. There were 2,413 pictorial symbols recorded, or an average of 6.5 items drawn per student. Compared to primary-school students, secondary-school students tended to write more and draw less. Specifically, the 348 maps they completed contained 3,603 text entries or an average of 10.4 items written per student and only 1,812 pictorial entries, representing an average of 5.2 items drawn per student (Table 2).

Table 2. Number of landscape features and characteristics entered on cognitive maps

Grade/Year	No. of written items	No. of written items per student	No. of drawn items	No. of drawn items per student	Total no. of items	Total no. of items per student
5 (primary school)	2,177	10.0	1,622	7.4	3,799	17.4
9 (primary school)	1,353	8.7	791	5.1	2,144	13.7
1 (secondary school)	1,849	10.9	982	5.8	2,831	16.7
3 (secondary school)	1,754	9.9	830	4.7	2,584	14.5
Total	7,133	9.9	4,225	5.9	11,358	15.7

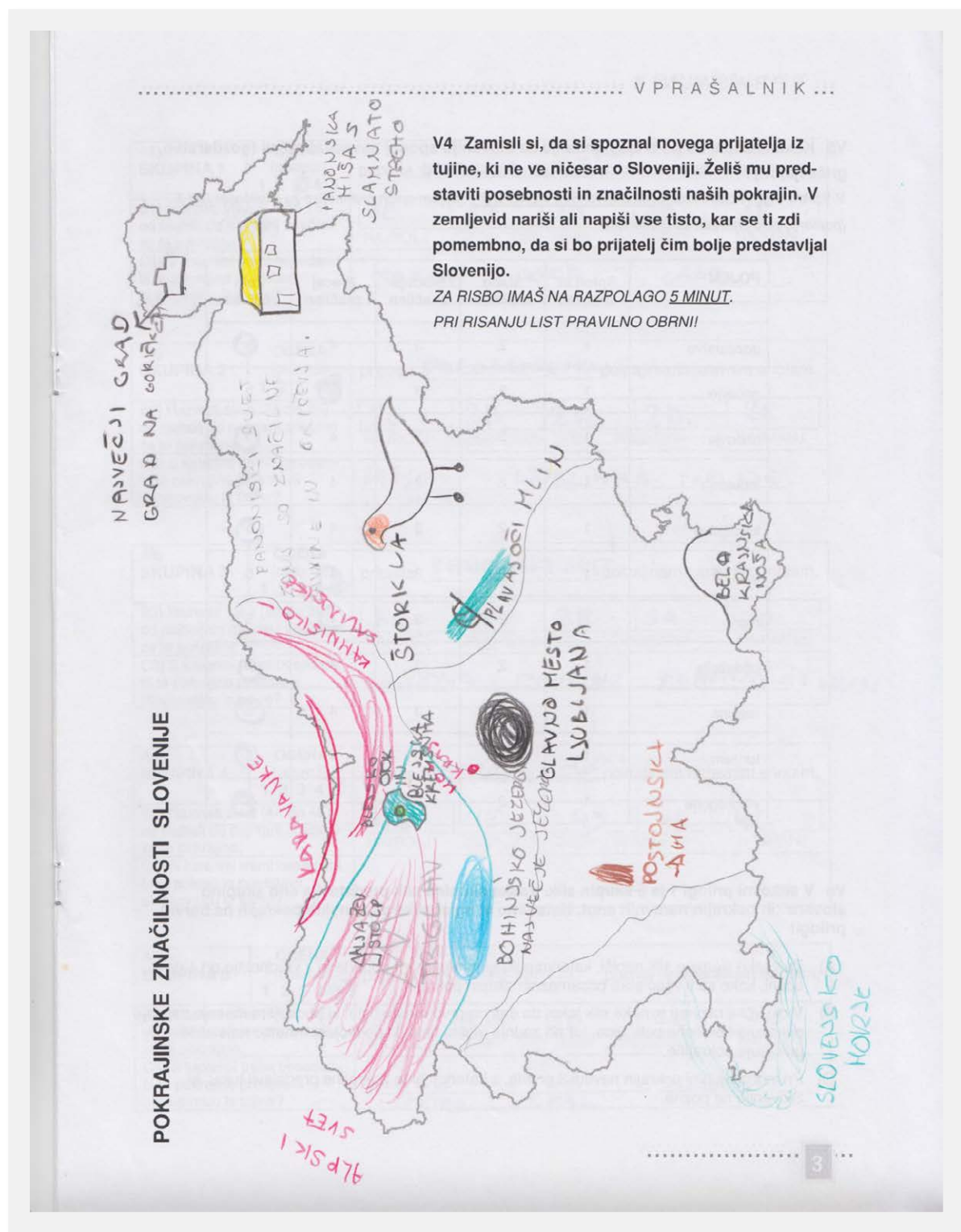


Fig. 4. Example of a cognitive map rich in drawn and written elements.

Both the secondary-school students (44.3%) and primary-school students (33.6%) included a large share of those that did not draw anything, but only wrote things on the map or turned in an empty map. When students decided to use a cartographic symbol to depict their spatial perceptions, they primarily opted for geometric symbols. Among the primary-school students, 37.8% did this, and the relevant share among the secondary-school students was only 3.3 percentage points smaller. Students most often decided to use dots, circles, and crosses; for line symbols they tended to use solid lines, and for area symbols they used uncolored polygons. There were only small differences in the choice of cartographic symbols between the two sexes, with girls slightly more often choosing crosses and boys usually choosing circles.

3.3 Students' spatial perceptions of Slovenia's landscape features and characteristics

The content of the maps was used to determine whether the students' home environment has a significant influence on their perceptions and whether spatial features closer to their home would predominate in what they marked. This was also expected because, according to the instructions accompanying the blank map, the students had to draw or write down what they would like to show a friend from abroad.

The analysis showed that the same features repeated on the maps regardless of where the students attended school. Fig. 5 shows slightly larger shares of illustrations or text entered in their home landscapes compared to other landscapes. However, these differences are negligible, especially because the things that the students wanted to show a friend from abroad most often included natural and cultural sites across all of Slovenia, the attractive images of which regularly appear in tourist guides, on TV, and on the internet. Therefore, these sites feel closer to them, although they probably have not yet visited most of them themselves.

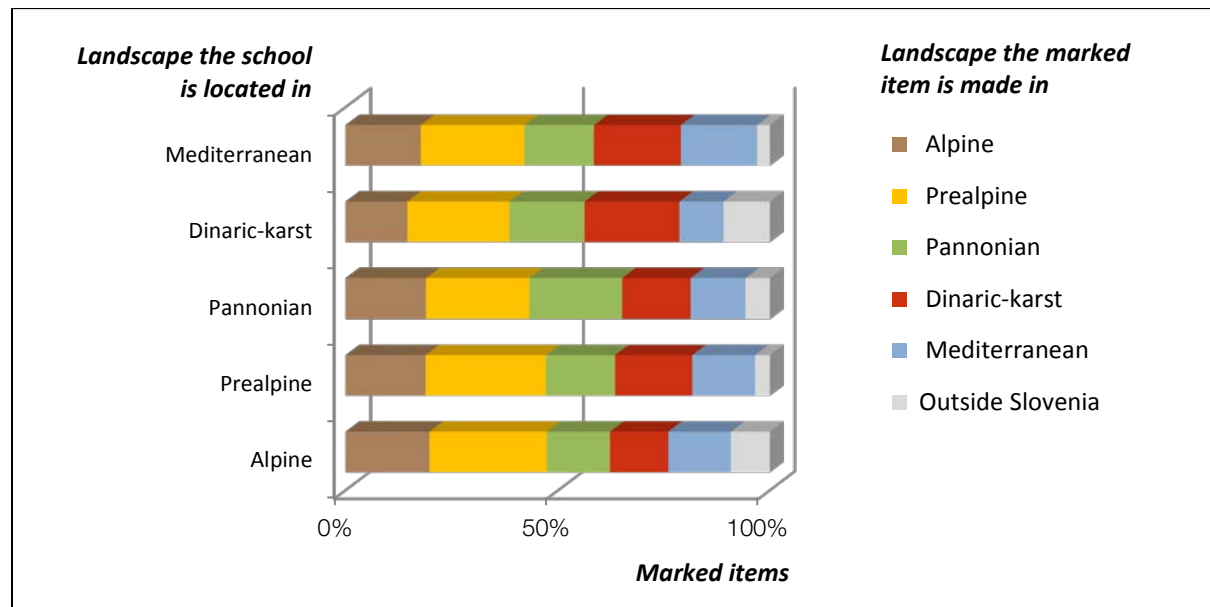


Fig. 5. Share of features or characteristics referring to an individual natural geographical landscape provided by students.

The students' perceptions also mirror what they learned in school, which primarily derives from the prescribed curricula and textbooks. This was evident from 16.7% of entries, which refer to material that would be difficult to show to someone because certain phenomena are the result of scientific conclusions or are very difficult to see in the natural environment. The most illustrative example of this refers to the division and names of natural geographical landscapes (Fig. 6). To a smaller degree, this also refers to landscape types (mountains, hills, valleys, and plains), names of Slovenia's neighboring countries (Fig. 6) and traditional regions (Prekmurje, Upper Carniola, Lower Car-

niola, Styria, Inner Carniola, and Carinthia), water bodies with the names of some rivers, Slovenia's road network, the names of animals difficult to spot in the wild (bears, lynxes, and wild goats), customs (Zeleni Jurij 'a St. George's Day figure' and Laufarji 'Cerkno carnival figures'), and minorities in Slovenia (the Italian and the Hungarian minority, bilingualism). This testifies to the fact that education is leaving visible traces in children's geographical perceptions because they take them out of their mental world and include them in their cognitive maps, even though that is not demanded in the instructions. Children clearly associate the term "map" itself with school maps.

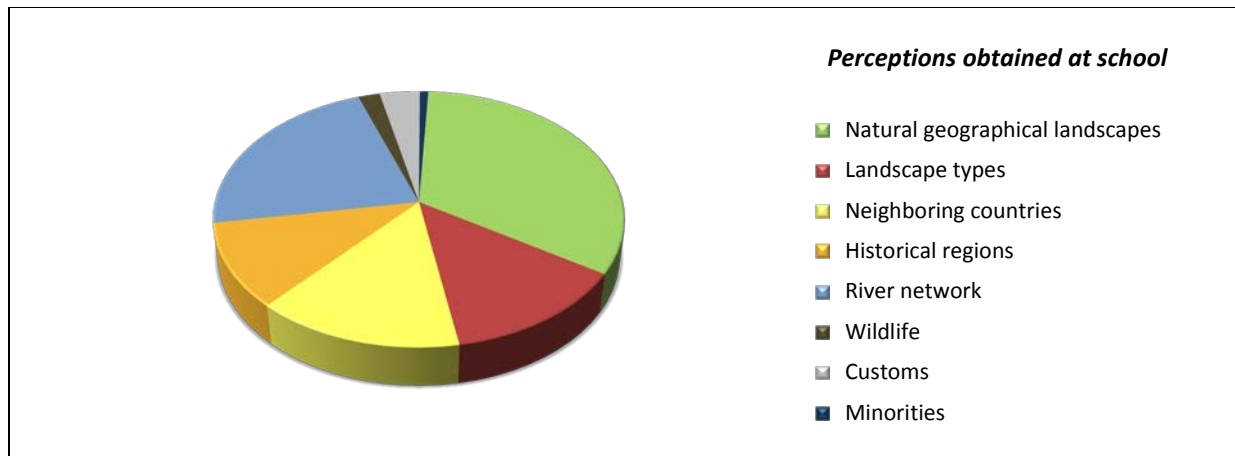


Fig. 6. School knowledge mirrored in the predominant depiction of natural geographical units.

Considering that they have been in school longer and have had increased opportunities to gain real-life experience or obtain information through the media, secondary-school students were expected to be more innovative in marking various characteristics or to mark a greater variety of items and show better knowledge of Slovenia. However, after all of the 7,133 entries had been categorized in terms of grammar and semantics, what was left was only 320 different terms. Predominating among the names of towns were Ljubljana, Maribor, Bled, Koper, and Piran, and the predominant regions listed were the Julian Alps, the Karst Plateau, and White Carniola. Lake Bled and the Soča, Mura, and Sava rivers predominated among the water features, and with regard to cuisine the students tended to give priority to Bled cream pastry, Prekmurje layered pastry, and cherries (Fig. 7).



Fig. 7. Perceptions of Slovenia's features and characteristics by primary-school students (left) and secondary-school students (right). (Source: Fridl 2016, 173)

Specifically, among the 320 terms used, 165 were the same and were listed once or several times by both primary- and secondary-school students. Sixty-five terms (20%) were only listed by primary-school students and ninety (28%) only by secondary-school students. The difference of eight percentage points was smaller than expected.

4. Conclusions

In the survey, the majority of students and teachers confirmed the fact that school maps contribute significantly to a better learning process. Today, school maps are most often used for reviewing material learned in school and least often for orientation. This results from the predominance of navigation devices. The use of maps also has a beneficial effect on shaping mental images of geographical reality. This was also confirmed by the replications of spatial perceptions on the cognitive maps. Even though in practice cognitive maps are commonly used by psychologists and spatial development planners, they can also be useful for determining differences in perceptions of geographical reality, examining students' conceptual and perceptual knowledge, and the impact of the educational process on individuals' perceptions. Perhaps it was incorrectly anticipated that the students would primarily draw places that were closer to and more familiar to them. However, the analysis showed that the students most often included the same landscape features and characteristics on their maps regardless of where they attended school. With regard to content, the differences in perception between primary-school and secondary-school students were less significant than anticipated. Their pictures also reflected concepts they had learned in school when they marked features that cannot be pointed to in the natural world, such as the borders of physical geographical regions and the names of Slovenia's neighboring countries and traditional regions. Also interesting are the methods and techniques the students used for representing their perceptions on cognitive maps. No major differences were established between primary-school and secondary-school students or between the two sexes in presenting cartographic facts.

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